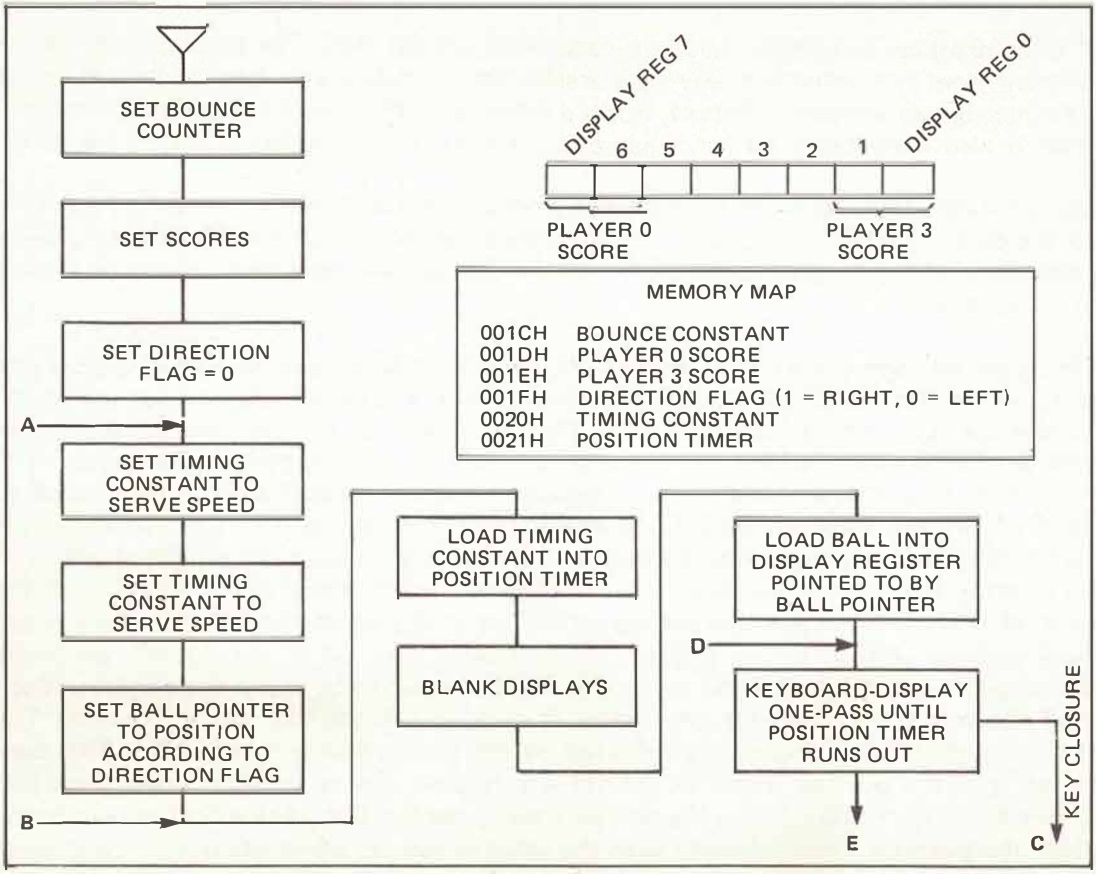
Enough of these practical programs. Let's do something just for fun. The program that we are about to present does not introduce any new instructions, frankly you now know just about the entire instruction set anyway. Instead, this is a down to earth example of real programming. The fact that it also happens to be for a game that's a lot of fun to play is beside the point.

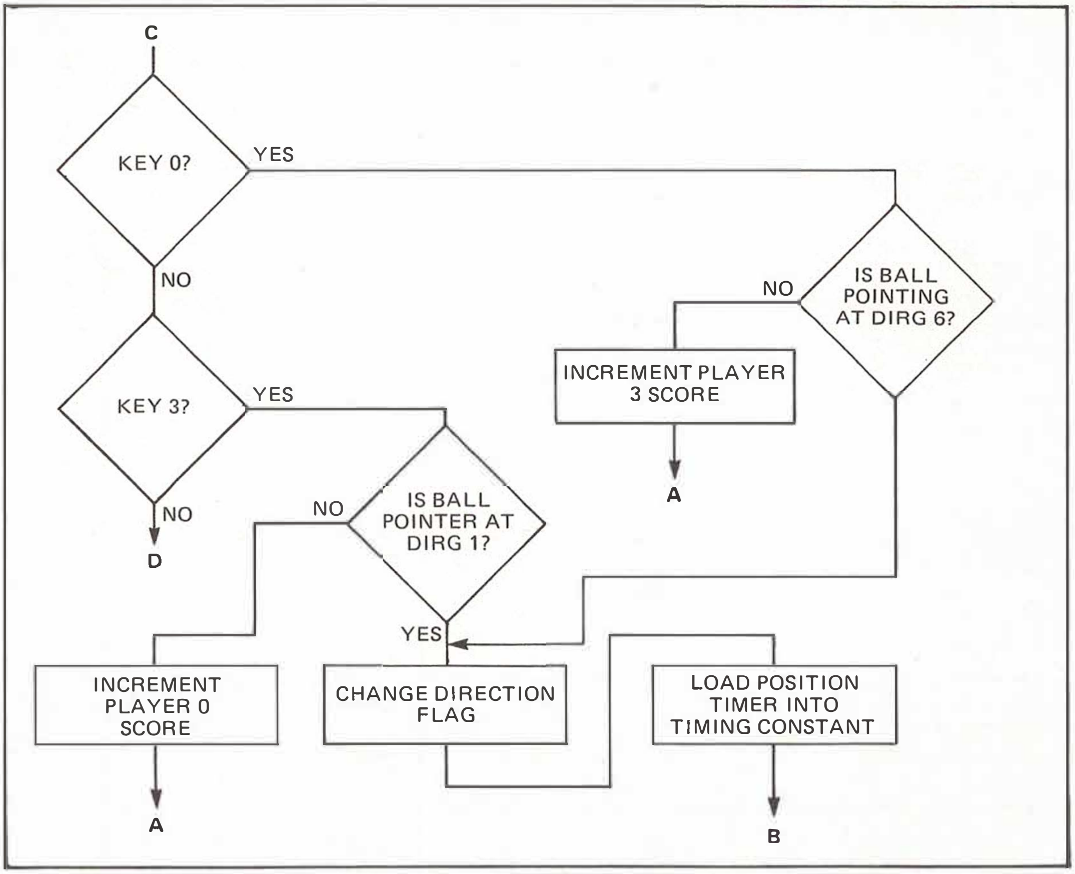
To understand this program we need to study the flow diagram and memory map in Fig. 10-1. This details the operation of the program. That diagram together with a little explanation should make the operation of the program clear. Turn to the diagram and refer to it now as we discuss the flow of the program.

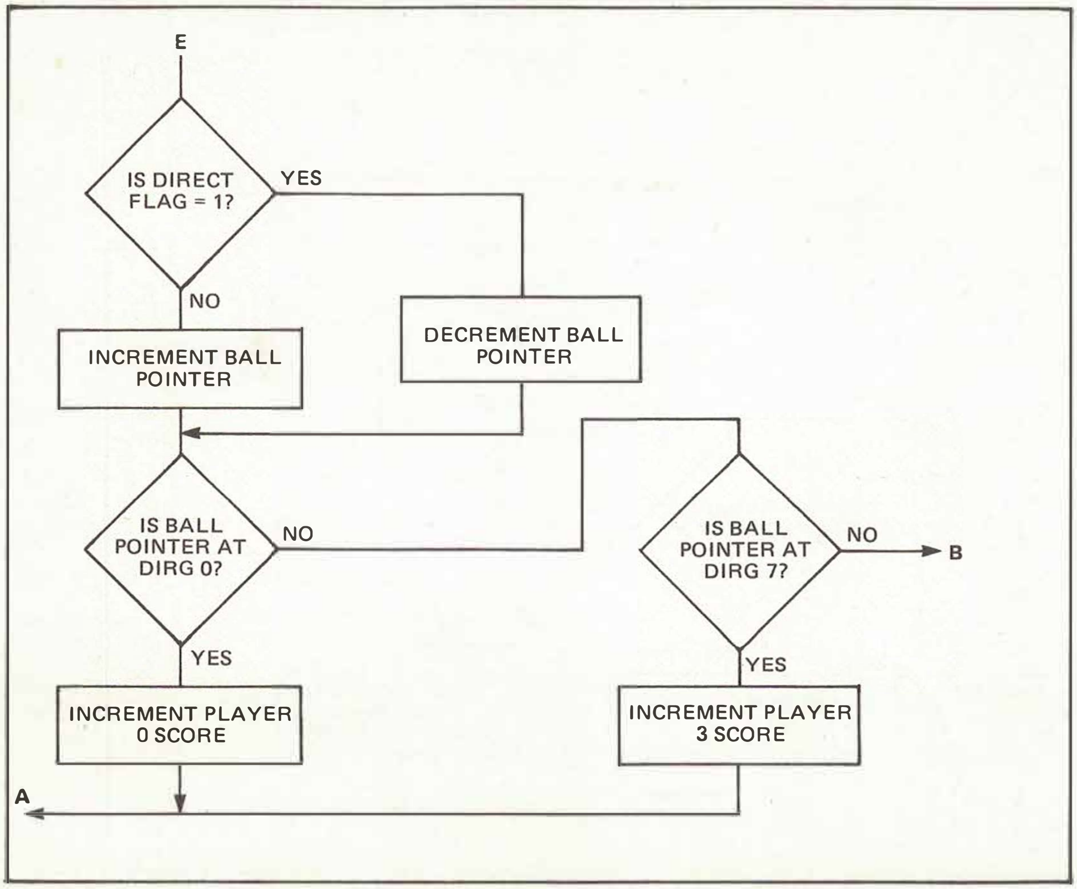
Since this program will use the KEYBOARD-DISPLAY ONE PASS subroutine developed as one of our utility subroutines in Chapter Eight, we need to allot a memory location for use as the bounce counter for debouncing the keyboard. That location is at 001CH. Immediately after this, at locations 001DH and 001EH, are the registers used for storing the players scores. The players are referred to as Player 0 and Player 3 because these are the keys the two players use to control the direction and speed of the ball. Location 001FH is used to store a direction flag. A 01H in this location tells the computer the ball is to be moving to the right on the displays. A 00H in this location tells the computer to move the ball to the left across the displays. Once the ball has been set into motion across the displays it will travel at a constant velocity, spending the same amount of time at each of the display LEDs. During play, all of the displays are blank except for a single 1 that represents the ball. This flies back and forth across the displays. Each player "hits" the ball by pressing his key, either 0 or 1, just as the ball gets to his end. The amount of time spent in each display is controlled by the timing constant in 0020H. That constant is moved into the position timer at 0021H which then acts as a loop counter for KEYBOARD DISPLAY ONE PASS. When the position timer reaches 00H, the ball is moved to the next location, the position timer reloaded with the value of the timing constant, and the process started over.


SET BOUNCE COUNTER
SET SCORES
SET DIRECTION FLAG = 0
A
SET TIMING CONSTANT TO SERVE SPEED
SET TIMING CONSTANT TO SERVE SPEED
SET BALL POINTER TO POSITION ACCORDING TO DIRECTION FLAG
B
LOAD TIMING CONSTANT INTO POSITION TIMER
BLANK DISPLAYS
LOAD BALL INTO DISPLAY REGISTER POINTED TO BY BALL POINTER
D
KEYBOARD-DISPLAY ONE-PASS UNTIL POSITION TIMER RUNS OUT
KEY CLOSURE
E
C
DISPLAY REG 7
6
5
4
3
2
1
DISPLAY REG 0
PLAYER 0 SCORE
PLAYER 3 SCORE
MEMORY MAP

MEMORY MAP	
001CH	BOUNCE CONSTANT
001DH	PLAYER 0 SCORE
001EH	PLAYER 3 SCORE
001FH	DIRECTION FLAG (1 = RIGHT, 0 = LEFT)
0020H	TIMING CONSTANT
0021H	POSITION TIMER

Fig. 10-1. Flow diagram and memory map of PING-PONG program.


C
KEY 0?
YES
NO
KEY 3?
YES
NO
D
IS BALL POINTING AT DIRG 6?
NO
INCREMENT PLAYER 3 SCORE
A
IS BALL POINTER AT DIRG 1?
NO
YES
INCREMENT PLAYER 0 SCORE
A
CHANGE DIRECTION FLAG
LOAD POSITION TIMER INTO TIMING CONSTANT
B


E
IS DIRECT FLAG = 1?
YES
NO
INCREMENT BALL POINTER
DECREMENT BALL POINTER
IS BALL POINTER AT DIRG 0?
NO
YES
IS BALL POINTER AT DIRG 7?
NO
B
YES
INCREMENT PLAYER 0 SCORE
INCREMENT PLAYER 3 SCORE
A

At all times the computer is monitoring the keyboard waiting for a key closure. The only time a key closure should occur is when the ball is in display register no. 6 or display register no. ~~5~~1. If either party presses a key at any other time, it counts against him and the other player scores. When the ball approaches the left end of the displays, Player 0 gets ready and presses key 0 during the time the ball is in display digit no. 6. If he waits a bit too long and the ball reaches the last digit, the computer treats this as having "missed" the ball and awards the other player the score. If Player 0 successfully presses key 0 while the ball is in display digit no. 6, the computer changes the direction flag and sends the ball back across the displays toward player 3. To make the game more interesting, the computer loads the timing constant register with the value left in the position timer. Since this timer had presumably counted down part way before player 0 pressed his key, the position timer now contains a number that is smaller than that in the timing constant. By loading the value of the position timer back into the timing constant, it will be this new, smaller value that determines how long the ball is in each display digit. This has the effect of making the game run a little faster on each trip back across the displays. With a little practice a good player can return the ball so fast it is barely visible. After each point, the scores come up for about two seconds and then another serve occurs.

PING-PONG

```
0100    21    LXI    H, 001CH         ;Set bounce counter at 001CH
0101    1C                            ;to 01H so EXC key will
0102    00                            ;not cause valid closure.
0103    36    MVI    M,01H            ;
0104    01                            ;
0105    AF    XRA    A                ;Zero out accumulator and use
0106    23    INX    H                ;it to zero out scores and
0107    77    MOV    M, A             ;direction flag.
0108    23    INX    H                ;
0109    77    MOV    M, A             ;
```

```
010A    23    INX    H                   ;
010B    77    MOV    M, A                ;
010C    CD    CALL BLANK (80CCH)         ;Blank displays in preparation
010D    CC                               ;for displaying scores.
010E    80                               ;
010F    11    LXI    D, 001EH            ;Point D/E to Player 3 score.
0110    1E                               ;Load accumulator with this score
0111    00                               ;and CALL SUB3A to display
0112    1A    LDAX   D                   ;it in displays 1 and 0.
0113    CD    CALL   SUB3A (809AH)       ;
0114    9A                               ;
0115    80                               ;
0116    1D    DCR    E                   ;Point D/E to Player 0 score.
0117    21    LXI    H, 000FH            ;Point H/L to display register no. 7
0118    0F                               ;and load C with 02H.  This sets
0119    00                               ;up the registers for CALLing
011A    0E    MVI    C, 02H              ;SUB3 which will display
011B    02                               ;Player 3 score in displays 6 and 7.
011C    1A    LDAX   D                   ;
011D    CD    CALL SUB3 (80A5H)          ;
011E    A5                               ;
011F    80                               ;
0120    06    MVI    B, FFH              ;Load B with 2-second count for
0121    FF                               ;displaying scores for 2 seconds.
0122    CD    CALL CONVERT (8132H)       ;Convert display registers to
0123    32                               ;7-segment code and load into
0124    81                               ;display buffers.
0125    CD    CALL KYBD DSP (0311H)      ;Display scores and monitor keyboard.
0126    11                               ;When key closure found, go back
0127    03                               ;to 0125H for loop.  If no key
0128    25    JUMP ADDRESS (0125H)       ;closure found, fall through to
0129    01                               ;012AH to decrement 2-second counter.
```

```
012A    05    DCR    B              ;
012B    C2    JNZ    0125H          ;Set up loop.
012C    25                          ;
012D    01                          ;
012E    3E    MVI    A, 80H         ;Set timing constant to serve
012F    80                          ;speed.
0130    32    STA    0020H          ;
0131    20                          ;
0132    00                          ;
0133    3A    LDA    001FH          ;Determine whether direction flag
0134    1F                          ;is a 0 or a 1.  If 0, set H/L,
0135    00                          ;which serve as the ball pointer,
0136    B7    ORA    A              ;to 000AH, digit no. 2.  If 1, set
0137    CA    JZ     0140H          ;H/L to 000DH, digit no. 5.
0138    40                          ;
0139    01                          ;
013A    21    LXI    H, 000DH       ;
013B    0D                          ;
013C    00                          ;
013D    C3    JMP    0143H          ;
013E    43                          ;
013F    01                          ;
0140    21    LXI    H, 000AH       ;
0141    0A                          ;
0142    00                          ;
0143    3A    LDA    0020H          ;Load timing constant at 0020H into
0144    20                          ;position timer at 0021H.
0145    00                          ;
0146    32    STA    0021H          ;
0147    21                          ;
0148    00                          ;
```

```
0149    CD      CALL BLANK (80CCH)      ;Blank displays in preparation
014A    CC                              ;for displaying ball.
014B    80                              ;
014C    3E      MVI     A, 01H          ;Load 01H, the ball, into the
014D    01                              ;display register pointed to by
014E    77      MOV     M, A            ;the ball pointer, H/L.
014F    CD      CALL CONVERT (8132H)    ;Convert displays to 7-segment code.
0150    32                              ;
0151    81                              ;
0152    3A      LDA     0021H           ;Load position timer into accum
0153    21                              ;and decrement.
0154    00                              ;
0155    3D      DCR     A               ;
0156    32      STA     0021H           ;Load adjusted value back
0157    21                              ;into memory.
0158    00                              ;
0159    CA      JZ      0164H           ;If the position timer is zero,
015A    64                              ;jump out of the loop to move
015B    01                              ;the ball.  If not, display the
015C    CD      CALL KB DSPLY (0311H)   ;ball for one more loop.
015D    11                              ;
015E    03                              ;
015F    93      JUMP ADDRESS (0193H)    ;If a key closure occurs during
0160    01                              ;this time, go to 0193H to process it.
0161    C3      JMP     0152H           ;
0162    52                              ;
0163    01                              ;
0164    3A      LDA     001FH           ;The position timer has timed out.
0165    1F                              ;Load the accum with the direction
0166    00                              ;flag to find out which way to move
0167    B7      ORA     A               ;the ball.  If flag = 0, increment
```

```
0168      CA      JZ      016FH          ;H/L ball pointer to move it to
0169      6F                             ;the left.  If flag = 1, decrement
016A      01                             ;H/L to move it to the right.
016B      2B      DCX     H              ;
016C      C3      JMP     0170H          ;
016D      70                             ;
016E      01                             ;
016F      23      INX     H              ;
0170      7D      MOV     A, L           ;Check to see if ball pointer at
0171      FE      CPI     08H            ;digit no. 0.  If it is, increment
0172      08                             ;Player 0 score.  If not, go to
0173      C2      JNZ     0182H          ;0182H.
0174      82                             ;
0175      01                             ;
0176      3A      LDA     001DH          ;
0177      1D                             ;
0178      00                             ;
0179      C6      ADI     01H            ;
017A      01                             ;
017B      27      DAA                    ;
017C      32      STA     001DH          ;
017D      1D                             ;
017E      00                             ;
017F      C3      JMP     010CH          ;If player 0 scored, go back to
0180      0C                             ;beginning and serve again.
0181      01                             ;
0182      FE      CPI     0FH            ;Check to see if ball pointer at
0183      0F                             ;digit no. 7.  If it is, increment
0184      C2      JNZ     0143H          ;Player 3 score.  If not, go to
0185      43                             ;0143H to display ball
0186      01                             ;in another digit location.
```

```
0187    3A    LDA    001EH           ;
0188    1E                           ;
0189    00                           ;
018A    C6    ADI    01H             ;
018B    01                           ;
018C    27    DAA                    ;
018D    32    STA    001EH           ;
018E    1E                           ;
018F    00                           ;
0190    C3    JMP    010CH           ;
0191    0C                           ;
0192    01                          ;
0193    FE    CPI    00H            ;A key closure has been found.  Is
0194    00                          ;it 0?  Go to 01BBH for processing.
0195    CA    JZ     01BBH           ;
0196    BB                           ;
0197    01                           ;
0198    FE    CPI    03H            ;Is it 3?  Go to 019DH for processing.
0199    03                          ;If neither 0 or 3, ignore by
019A    C2    JNZ    014FH          ;going back to 014FH.
019B    4F                           ;
019C    01                          ;
019D    7D    MOV    A, L           ;A 3 key has been found.  Does ball
019E    FE    CPI    09H            ;pointer point to digit no. 1?  If not,
019F    09                          ;go to 0176H and increment Player 0
01A0    C2    JNZ    0176H          ;score.
01A1    76                           ;
01A2    01                           ;
01A3    3A    LDA    001FH          ;If key 3 was closed during digit 1,
01A4    1F                          ;then complement direction flag.
01A5    00                           ;
01A6    B7    ORA    A               ;
```

```
01A7    CA    JZ     01AEH          ;
01A8    AE                          ;
01A9    01                          ;
01AA    3D    DCR    A              ;
01AB    C3    JMP    01AFH          ;
01AC    AF                          ;
01AD    01                          ;
01AE    3C    INR    A              ;
01AF    32    STA    001FH          ;
01B0    1F                          ;
01B1    00                          ;
01B2    3A    LDA    0021H          ;Load position timer into timing
01B3    21                          ;constant to make ball move faster.
01B4    00                          ;
01B5    32    STA    0020H          ;
01B6    20                          ;
01B7    00                          ;
01B8    C3    JMP    0143H          ;Go back and display ball moving in
01B9    43                          ;the opposite direction at the new
01BA    01                          ;speed.
01BB    7D    MOV    A, L           ;A 0 key has been found.  Does the
01BC    FE    CPI    0EH            ;ball pointer point to digit no. 6?
01BD    0E                          ;
01BE    C2    JNZ    0187H          ;If not, go to 0187H and increment
01BF    87                          ;player 3 score.
01C0    01                          ;
01C1    C3    JMP    01A3H          ;If yes, go and change direction
01C2    A3                          ;flag and send ball back in other
01C3    01                          ;direction at new speed.
```